CHAPTER (1) : CHARACTERISTICS OF FLUIDS

SI Units :

Quantity	units
Length	m
Mass	kg
Time	S
Velocity	m/s
Acceleration	m/s^2
Density	kg / m^3
Force	N = kg m/s^2
Pressure, stress	Pa = N/m^2
Energy, work	J
Viscosity	Pa s
Kinematic viscosity	m^2/s

$$\rho\ (\,density\,) = \frac{m}{v}$$

$$s\ (\,specific\ gravity\,) = \frac{\rho}{\rho_{water}}$$

$$v\ (\,specific\ volume\,) = \frac{1}{\rho} \quad (\frac{m^3}{kg})$$

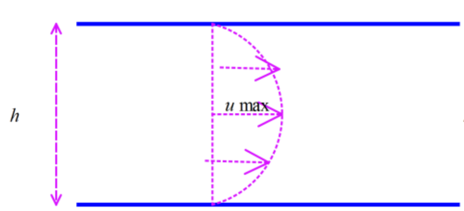
$$\tau\ (stress\,) = \frac{F}{A} = \mu\frac{U}{h}$$

$$F = \mu\, u\, A\frac{1}{h}$$

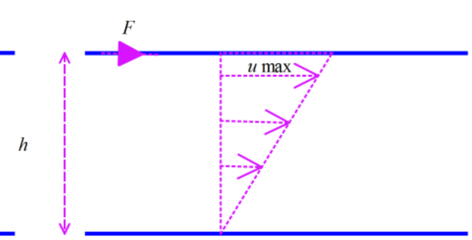
$$\mu = Viscosity \quad (\,poise = 100\ centi\ poise = 0.1\ Pa\ s \quad)$$

$$\upsilon = kinematics'viscosity = \frac{\mu}{\rho} \qquad (\,st = 1\frac{cm^2}{s} = 1 * 10^{-4}\frac{m^2}{s}\ ,,1\ cSt = 1 * 10^{-6}\frac{m^2}{s})$$

Pipe



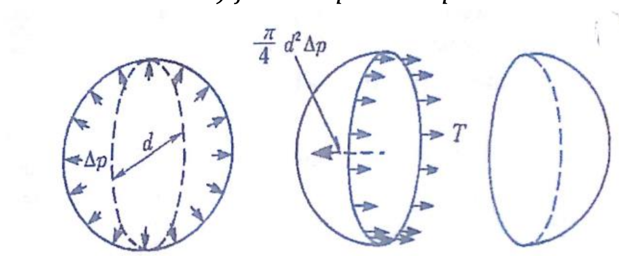
Two Plates



$$Newton's\ law\ of\ viscosity \qquad \tau = -\mu\,\frac{du}{dy} \quad ;\ F_D = \tau * A$$

$surface\ Tension\ \Delta P$

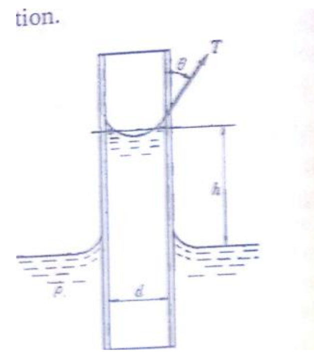
$A)\ for\ a\ liquid\ drop$



$$\frac{\pi}{4}\ d^2\ \Delta P = \pi d\ T$$

$$\therefore \Delta P = \frac{4T}{d}$$

B) for a tube



$$\pi\ d\ T cos\ \theta = \frac{\pi}{4}\ d^2\ \rho g h$$

$$\boldsymbol{h = \frac{4T\cos\theta}{\rho g d}}$$

$$h_{water} = \frac{30}{d}$$

$$h_{alcohol} = \frac{13.6}{d}$$

$$h_{Hg} = -\frac{10}{d}$$

All in mm

Compressibility

$$K\ (\ bulk\ modulus) = \frac{\Delta P}{\frac{\Delta V}{V}} = -V\frac{dP}{dV} = \rho\frac{dP}{d\rho} \quad (Pa)$$

$$\beta\ \ (compressibility\ ) = \frac{1}{K} \quad (\frac{1}{Pa})$$

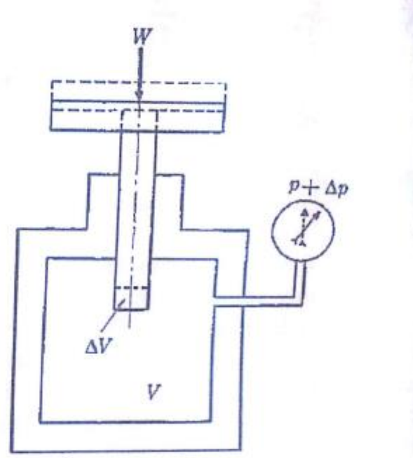
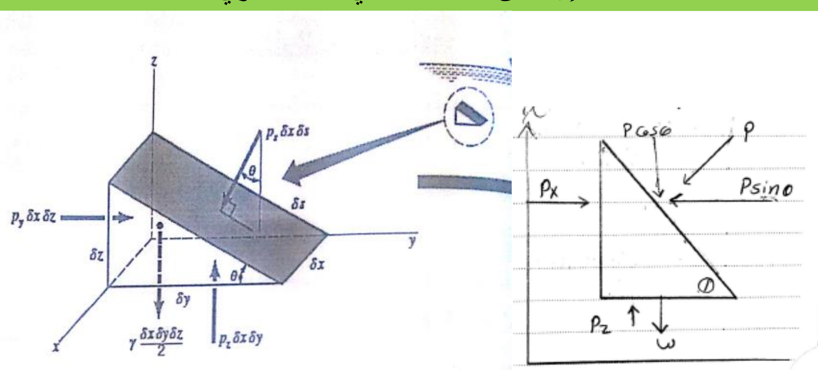


Fig. 1.8 Measuring of bulk modulus of fluid

$$a\ (\,velocity\ of\ propagatting\ liquid\,) = \sqrt{\frac{k}{\rho}} = \sqrt{\frac{dP}{d\rho}}$$

CHAPTER 2 : FLUID STATICS

إثبات ان الضغط عند أي نقطه متساوي



$$1)\quad \sum F_x = 0$$

$$P_x dz * 1 - P sin\theta * dl * 1 = 0$$

$$\sin\theta = \frac{dz}{dl}$$

$$P_x dz * 1 - P\ dz = 0$$

$$P = P_x$$

$$\therefore\quad at \sum F_y = 0 \quad P = P_y \qquad , at \sum F_z = 0 \quad P = P_z$$

$$\therefore\quad P = P_x = P_y = P_z$$

$$w(\,weight\,) = \rho g v = \rho g\ dx\ dy\ dz$$

Hydraulic Law

$$\boldsymbol{for\ incomprisable\ fluid}$$

$$\frac{dP}{dz} = \rho g$$

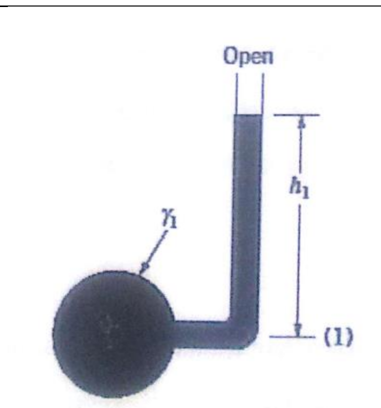
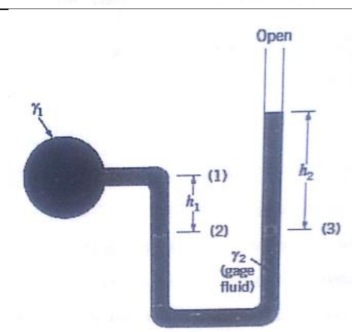
$$P = \rho g z = \rho g \overbrace{z}^{\text{distance from surface}}$$

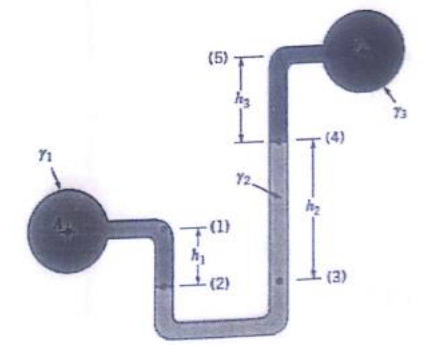
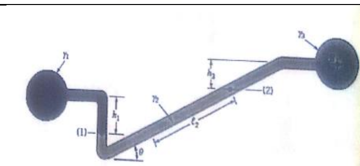
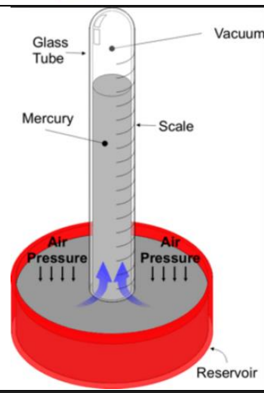
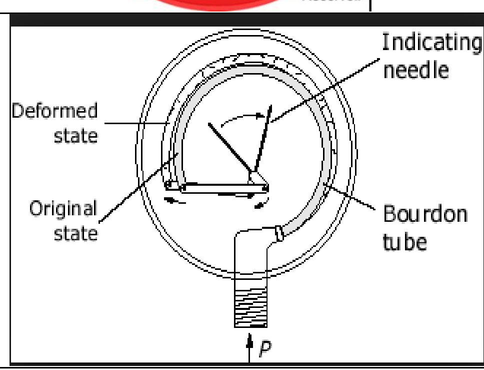
$$\boldsymbol{for\ comprisable\ fluid}$$

$$\frac{dp}{dz} = \frac{g}{R\text{الثابت العام للغازات}} * \frac{dz}{T}$$

$$(P_1 - P_2) = \rho g\ (Z_2 - Z_1)$$

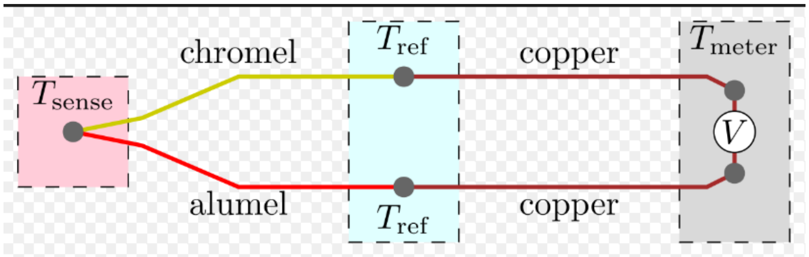
أجهزة قياس الضغط :

Piezometer		$P_A = \rho g\ h_1$
U tube manometer		$P_A = \rho g h_2 - \rho g\ h_1$

Differential U tube manometer		$P_B = P_A + \rho_1 g\, h_1 - \rho_2 g h_2 - \rho_3 g\, h_3$ $P_A - P_B = \rho_2 g h_2 + \rho_3 g\, h_3 - \rho_1 g\, h_1$
Inclined tube manometer		$P_B = P_A + \rho_1 g h_1 - \rho_2 g l_2 \sin\theta - \rho_3 g\, h_3$ $P_A - P_B = \rho_2 g l_2 \sin\theta + \rho_3 g\, h_3 - \rho_1 g h_1$
barometer		Measure P_{atm} $P_{atm} = 760\ mmHg$
Burdan Tube		Direct measure

أجهزة قياس الحراره

A- Thermocouple



B- Thermometer

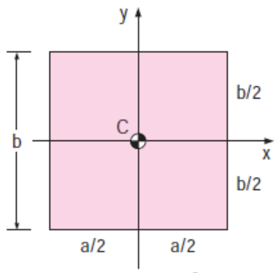
Gates :

يؤثر المائع على البوابه او السد او الجسم بقوه

$$\boldsymbol{F_R}\ (\ \boldsymbol{resultant\ Force}\ ) = \boldsymbol{PA} = \boldsymbol{\rho g h_c A} = \gamma h_c A = \gamma A y_c \sin\theta$$

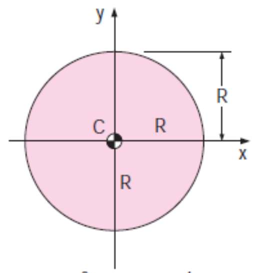
To determine the location of its effect

$$h_b = \boldsymbol{h_R} = \boldsymbol{h_c} + \frac{\boldsymbol{I_{xyc}}}{\boldsymbol{h_c A}}$$



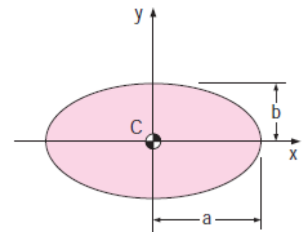
$A = ab$, $I_{xx,C} = ab^3/12$

(a) Rectangle



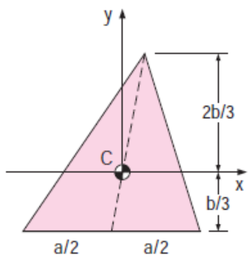
$A = \pi R^2$, $I_{xx,C} = \pi R^4/4$

(b) Circle



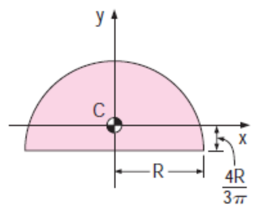
$A = \pi ab$, $I_{xx,C} = \pi ab^3/4$

(c) Ellipse



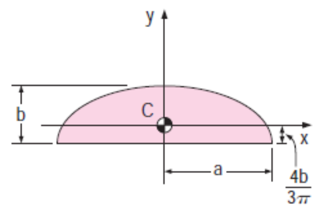
$A = ab/2$, $I_{xx,C} = ab^3/36$

(d) Triangle



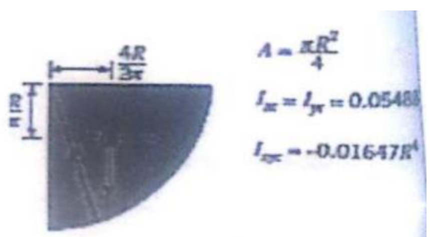
$A = \pi R^2/2$, $I_{xx,C} = 0.109757R^4$

(e) Semicircle



$A = \pi ab/2$, $I_{xx,C} = 0.109757ab^3$

(f) Semiellipse



Ch 3 : Dynamic Fluid

Classification of Fluid Flow

1- Steady or unsteady

Steady : السريان المستقر الذي لا تتغير خواصه مع الزمن

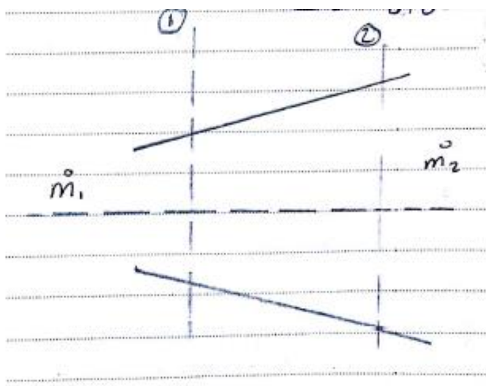
Unsteady : السريان الذي تتغير خواصه مع الزمن

2- Ideal or real Flow

Ideal : هو السريان المثالي الذي لا يوجد به فقد في الطاقة يهمل الاحتكاك الحادث بين المائع والانبوبه والاحتكاك بين جزيئات المائع معاً

Real : هو السريان الذي يأخذ في الاعتبار أي فقد في الطاقة الناتجة عن الاحتكاك

Continuity Equation :



Mass flow rate is constant $\frac{m}{t} = \dot{m} = \rho A V \quad (\frac{kg}{s})$

$$\dot{m}_1 = \dot{m}_2$$

For incompressible fluid

$\rho_1 = \rho_2$

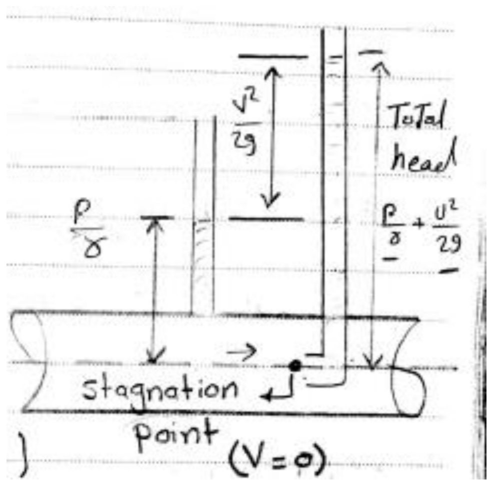
$\therefore \quad A_1 V_1 = A_2 V_2 = Q \quad (volume\ flow\ rate\ or\ discharge\ ) \ (\frac{m^3}{s})$

Pressure

$$Total\ Pressure\ = Static\ Pressure + Dynamic\ Pressure$$

$$Static\ Pressure\ = \rho gh = \gamma h$$
$$\gamma = specific\ weight = \rho g$$

To measure the total pressure we measure
static pressure + dynamic pressure



$$Total\ Head\ = \frac{P}{\gamma} + \frac{v^2}{2g}$$
$$\therefore \boldsymbol{Total\ pressure}\ = \boldsymbol{\gamma} \left(\frac{\boldsymbol{P}}{\boldsymbol{\gamma}} + \frac{\boldsymbol{v^2}}{\boldsymbol{2g}} \right) = \left(\boldsymbol{P} + \frac{\boldsymbol{\rho v^2}}{\boldsymbol{2}} \right)$$

اذن في أي مساله لحساب سرعه التدفق نحتاج *pizo tube + pitot tube*

و نحسب فرق الارتفاع بين السائل في كل منهم $\frac{v^2}{2g}$

Bernouli's Equation -> Ideal Flow

$$Total\ Power\ in\ Pipe = Total\ Power\ exit\ Pipe$$
$$Total\ Power = Pressure\ Energy + Kinetic\ Energy + Potential\ Energy$$

$$\boldsymbol{\frac{P_1}{\gamma} + \frac{v_1^2}{2g} + z_1 = \frac{P_2}{\gamma} + \frac{v_2^2}{2g} + z_2}$$

$$\boldsymbol{\frac{P_1}{\gamma} : Pressure\ Head\ \ (m)}$$

$$\boldsymbol{\frac{v_1^2}{2g} : Velocity\ \ Head\ (m)}$$

$$\boldsymbol{z : Potential\ Head\ \ (m)}$$

$$\frac{P}{\gamma} * mg + \frac{v^2}{2g} * mg + zmg = PAl + \frac{mv^2}{2} + zmg$$

CH 5 : COMBUSTION ENGINE

Internal combustion engine needs in order to run.

1- fuel
2- ignition
3- compression

*and has many **types** according to these parameters*

- *Four-Stroke Gasoline Engine*
- *Two-Stroke Gasoline Engines*
- *Diesel Engine*
- *Rotary Engine*
- *Steam Engine*

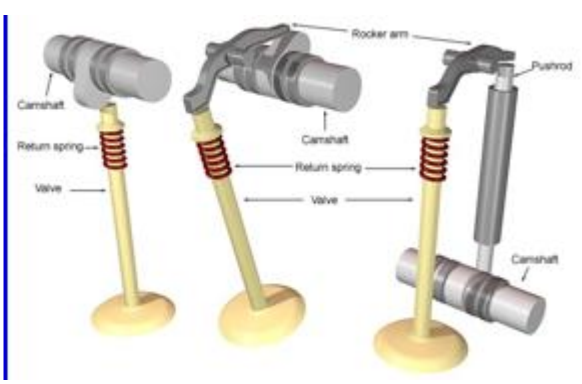
And according to Configuration

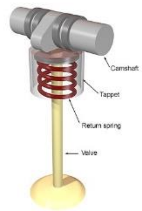
- *<u>Inline Engines</u>: The cylinders are arranged in a line, in a single bank.*
- *<u>V Engines</u>: The cylinders are arranged in two banks, set at an angle to one another.*
- *<u>Flat Engines</u>: The cylinders are arranged in two banks on opposite sides of the engine*

<u>Its Parts :</u>

1- Valves (minimum 2 valves)

- <u>Exhaust Valve</u> lets the exhaust gases escape the combustion Chamber. (Diameter is smaller then Intake valve)
- <u>Intake Valve</u> lets the air or air fuel mixture to enter the combustion chamber. (Diameter is larger than the exhaust valve)





Valve Springs: Keeps the valves Closed.

Valve Lifters: Rides the cam lobe and helps in opening the valves

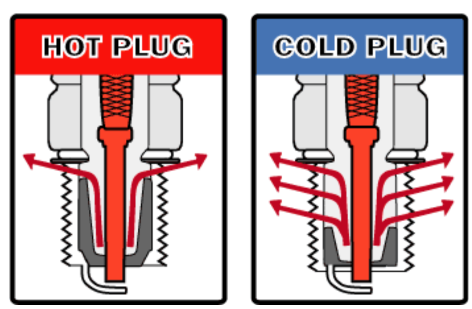
2- ***Cam Shaft*** *The shaft that has intake and Exhaust cams for operating the valves.*

3- ***Cam Lobe****: Changes rotary motion into reciprocating motion.*

Note ; Camshaft location is one way to classify engines. Overhead cam, SOHC, DOHC

4- ***Spark Plug*** *It provides the means of ignition when the gasoline engine's piston is at the end of compression stroke, close to Top Dead Center(TDC)*

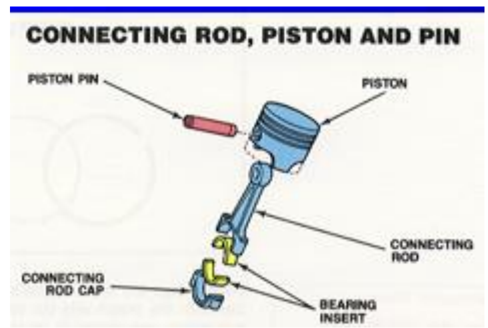
The difference between a "hot" and a "cold" spark plug is that the ceramic tip is longer on the hotter plug



5- *Piston* A movable part fitted into a cylinder, which can receive and transmit power.*Through connecting rod, forces the crank shaft to rotate.*

*6- **Connecting (conn.) Rod***

Attaches piston (wrist-pin) to the crank shaft (conn. rod caps).



*7- **Cylinder head***

Part that covers and encloses the Cylinder. It contains cooling fins or water jackets and the valves. Some engines contains the cam shaft in the cylinder head.

8- Engine block

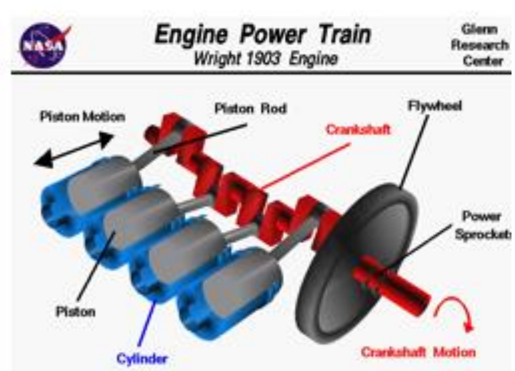
Foundation of the engine and contains pistons, crank shaft, cylinders, timing sprockets and sometimes the cam shaft. Also called short block.

Engine without cylinder heads, exhaust manifold, or intake manifold attached to it is called ***bare*** *block.*

9- Crank Shaft

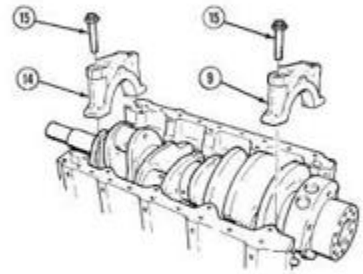
Converts <u>up and down</u> motion into circular motion.

Transmits the power to transmission.



10

Crank Shaft main bearings



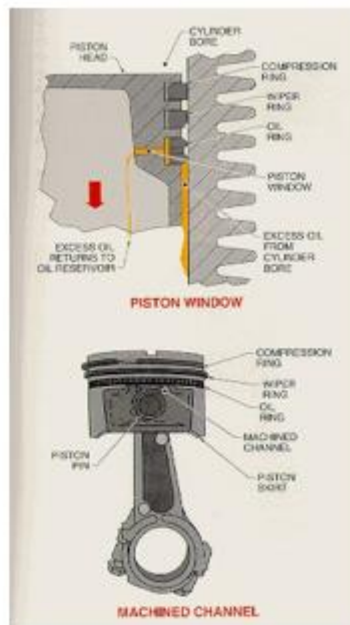
Main bearings are fitted between crank shaft and the main journals.

11

Piston Rings

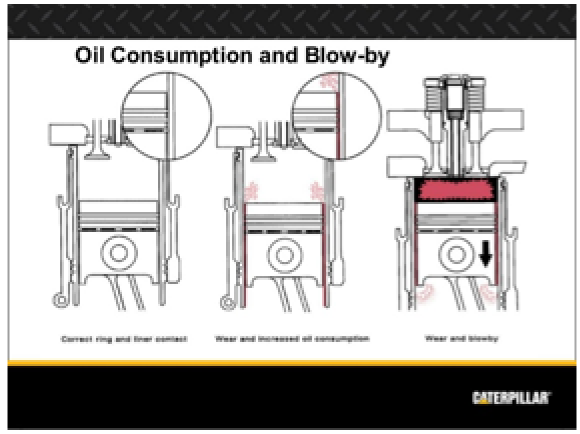
Four stroke: Three rings
Top two are compression rings (sealing the compression pressure in the cylinder) and the third is an oil ring (scrapes excessive oil from the cylinder walls)

Two Stroke: Two Rings
Both the rings are Compression rings.



Blow-by from Piston Rings

Engine blow-by will cause oil burning in the combustion chamber, producing blue(grey) smoke.



12

Flywheel

Attached to the crankshaft

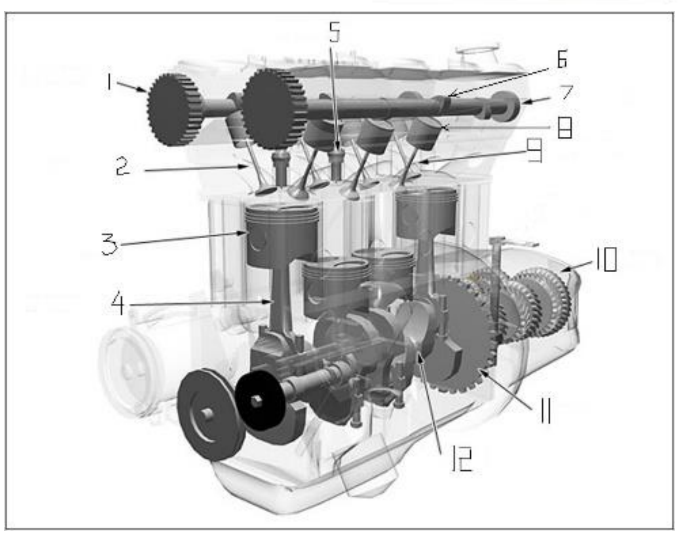
Reduces vibration

Cools the engine (air cooled)

Used during initial start-up

Transfers power from engine to Drivetrain

Helps glide through strokes

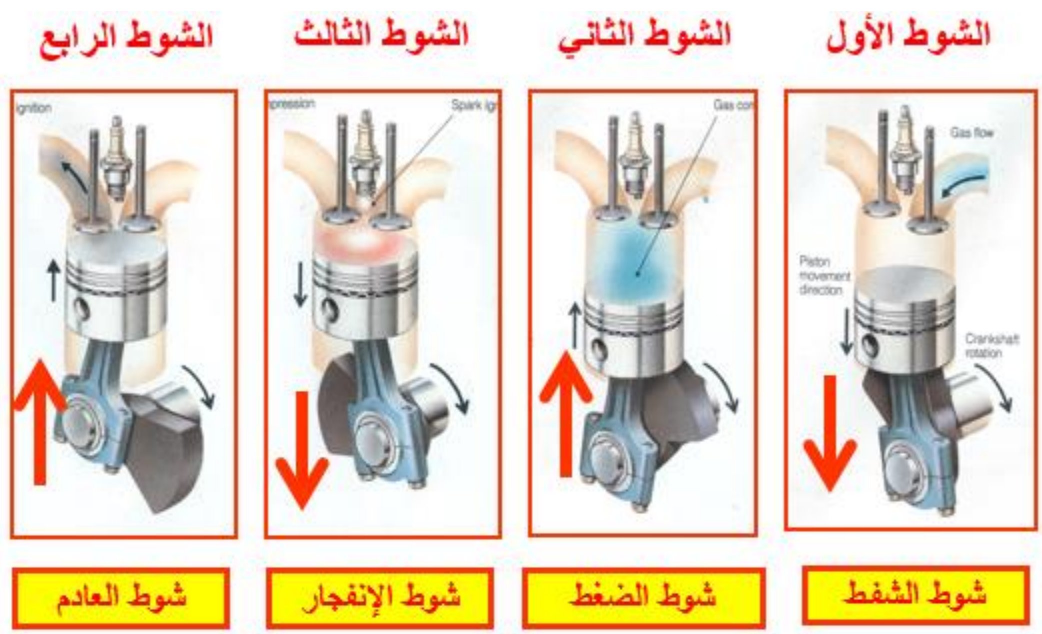


المكبس*Piston*

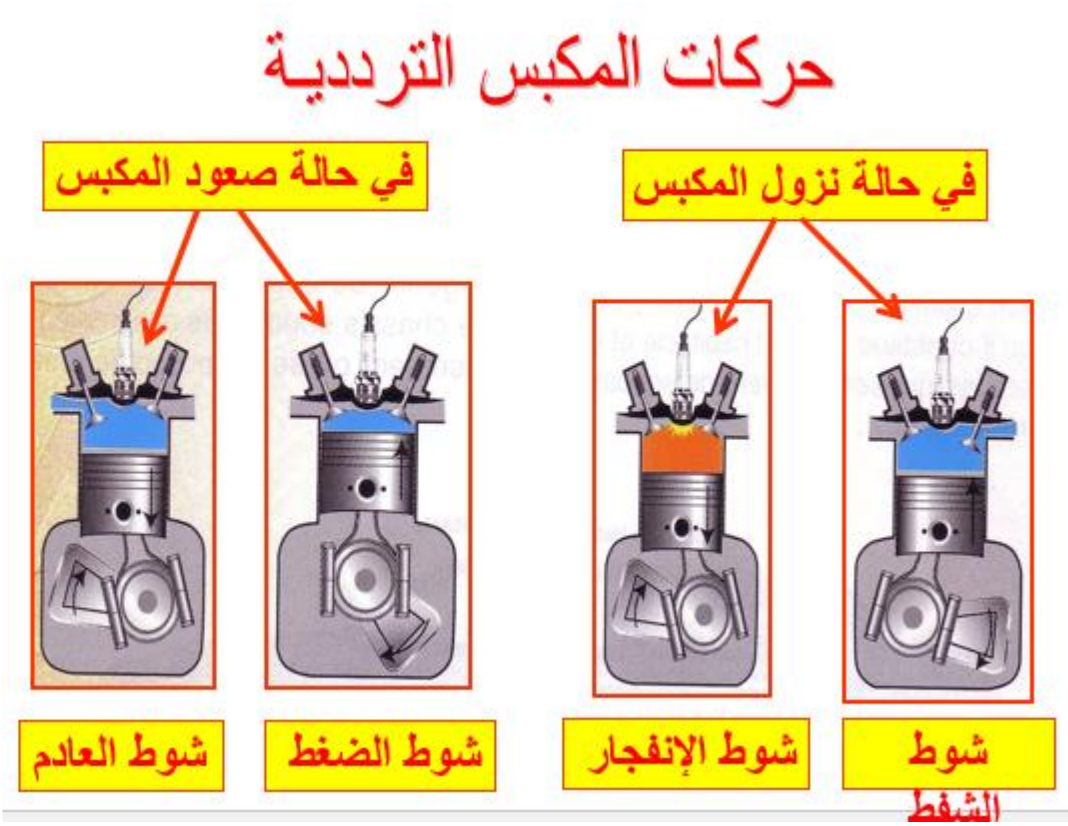
هو عبارة عن كتلة اسطوانية تتحرك حركة ترددية داخل جدار أو محيط إسطواني ، (يسمى الإسطوانة) ويتوافق معها في محركات الإحتراق الداخلي

(محركات السيارات) :

يصنع المكبس عادة من خليط من المعادن الخفيفة ، ويتكون الجزء العلوي منه من الرأس ومنطقة الرنجات بينما يتكون الجزء السفلي منه من الجذع . هو عبارة عن كتلة اسطوانية تتحرك حركة ترددية داخل جدار أو محيط إسطواني ، (يسمى الإسطوانة) ويتوافق معها .



في هذا الشوط يكون المكبس نازل ، وصمام الوقود مفتوح ، وصمام العادم مغلق ، يتم سحب خليط من الهواء والوقود لداخل إسطوانة المحرك عبر فتحة صمام الوقود ، تمهيداًً لشوط الضغط .	في هذا الشوط يكون المكبس صاعد ، وصمام الوقود مغلق ، وصمام العادم مغلق ، يتم ضغط خليط الهواءوالوقود داخل إسطوانة المحرك في غرفة الإحتراق ،تمهيداًً لشوط الإنفجار .	في هذا الشوط وقبل وصول المكبس الى النقطة الميتة العليا بعدة درجات ، تحدث شمعة الإحتراق (البوجيه) شرارة كهربائية تؤدي إلى حرق الخليط الذي تحول أصلاً إلى غاز وبفعل الحرق تتولد حرارة قوية جداً تؤدي إلى تمدد الغاز المحترق مما يؤدي إلى إندفاع المكبس للأسفل وهذا يسمى بشوط القدرة ، يكون صمام الوقود مغلق ، وصمام العادم مغلق أيضاً .	في هذا الشوط يكون المكبس صاعد ، وصمام الوقود مغلق ، وصمام العادم مفتوح ، يتم طرد غاز ثاني اوكسيد الكربون الناتج من عملية الإنفجار الى خارج إسطوانة المحرك عبر فتحة صمام العادم ، تمهيداً لسحب خليط جديد من الهواء والوقود في الشوط التالي .



حركات المكابس
والصمامات في المحرك لعملية الأشواط الأربعة

شوط المكبس	حركة المكبس	صمام الوقود	صمام العادم	شمعة الإحتراق
الشفط	نزول ↓	مفتوح	مغلق	------
الضغط	صعود ↑	مغلق	مغلق	------
الإنفجار	نزول ↓	مغلق	مغلق	شرارة
طرد العادم	صعود ↑	مغلق	مفتوح	------

قوانين لحل المسائل

- *Engine Performance*

$$\boldsymbol{Stroke\ Volume}\ \text{حجم الشوط}\ = \boldsymbol{A * S = \frac{\pi}{4} D^2 * S}$$

$$\boldsymbol{Compression\ ratio = \frac{V_S + V_C}{V_C}}$$

$$\boldsymbol{Engine\ Capacity\ per\ sec. = \frac{A * S * n * N}{60 * z}}$$

$$z = 1\ \ (2\ stroke\ engine\ )\ , z = 2\ (\ 4\ stroke\ engine\ )$$

$$n = number\ of\ cylinders\ \ , N \rightarrow R.P.M$$

Power :

(i.m.e.p) الضغط المتوسط البياني : هو الضغط الناتج من اشتعال الشراره الكهربية و هو قيمه متوسطه بين العظمى والصغرى

Indicated Power : (Pi)

$$P_i = \frac{(i.m.e.p) * A * S * n * N}{60 * z} \quad (W)$$

$$(b.m.e.p): indicated\ mean\ efficient\ power$$

Break Power output power (Pb) القوة الفرملية

$$P_b\ =\ T * \omega\ \ \ = (F * r)\ *\ \left(\frac{2\pi N}{60}\right)$$

$$P_b = \frac{(b.m.e.p) * A * S * N * n}{60 * z}$$

$$(b.m.e.p): break\ mean\ efficient\ power$$

Therrmal Efficiency

1-indicated thermal efficiency

$$\boldsymbol{\eta_{(th)_i}\ \ = \frac{P_i}{\dot{Q}_f}}$$

$$\boldsymbol{\dot{Q}_f}\ = heat\ added\ to\ engine = \boldsymbol{\dot{m}_f * C.V}$$

$$\dot{m}_f\ : rate\ of\ fuel\ consumption$$

$$C.V\ : heating\ value\ \left(\frac{KJ}{Kg}\right)$$

2-Brake Thermal Efficiency

$$\boldsymbol{\eta_{(th)_b}} = \frac{\boldsymbol{P_b}}{\boldsymbol{\dot{Q}_f}}$$

Mechanical Efficiency

$$\eta_m = \frac{P_o}{P_i} = \frac{P_b}{P_i}$$

Specific fuel consumption

-indicated specific fuel consumption

$$SFC_i = \frac{\dot{m}_f}{P_i} \quad \left(\frac{kg}{kW.h}\right)$$

$$\dot{m}_f \left(\frac{kg}{h}\right)$$

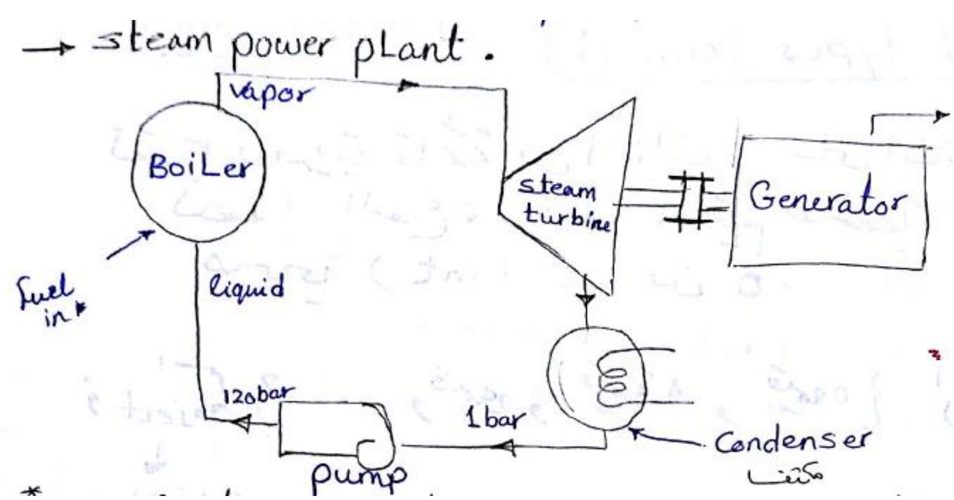
Brake Specific fuel consumption

$$SFC_b = \frac{\dot{m}_f}{P_b} \quad \left(\frac{kh}{kW.h}\right)$$

BOILERS

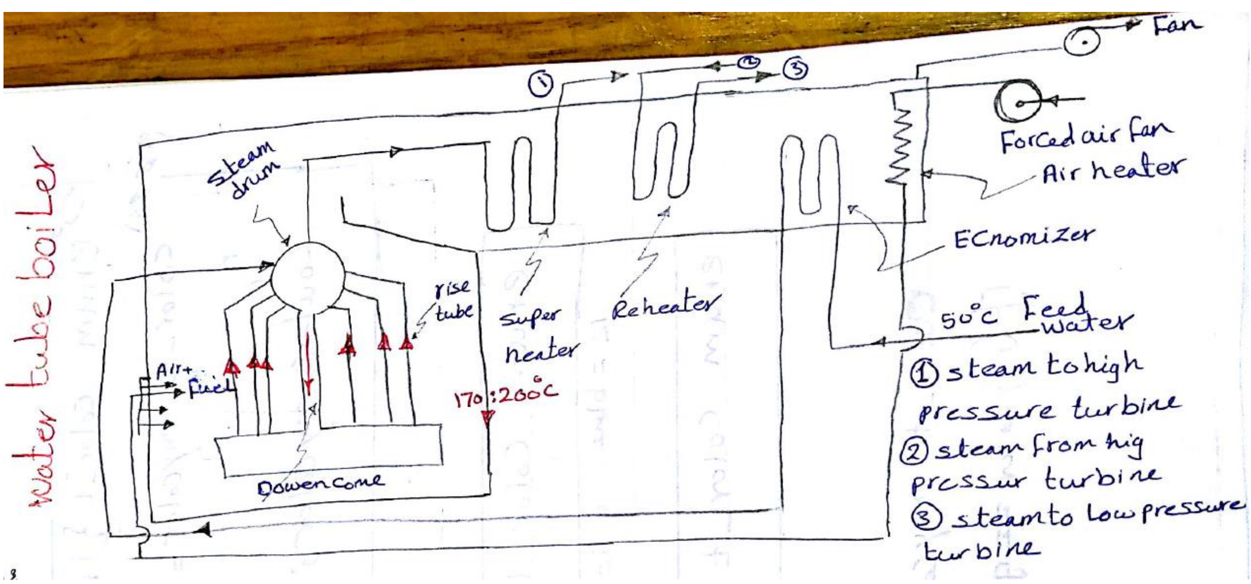
Function of boilers : Convert the water from liquid form to vapor form

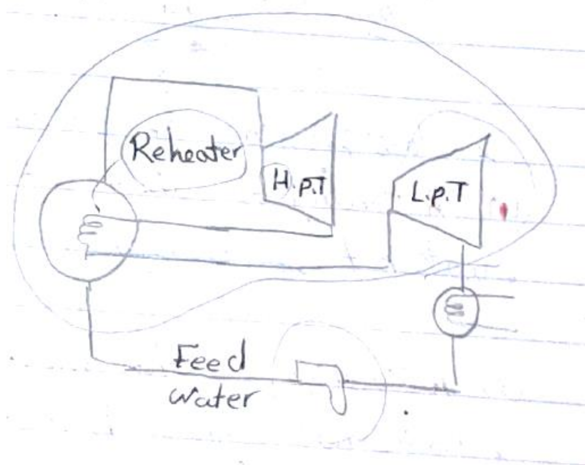
Figure of steam power plant



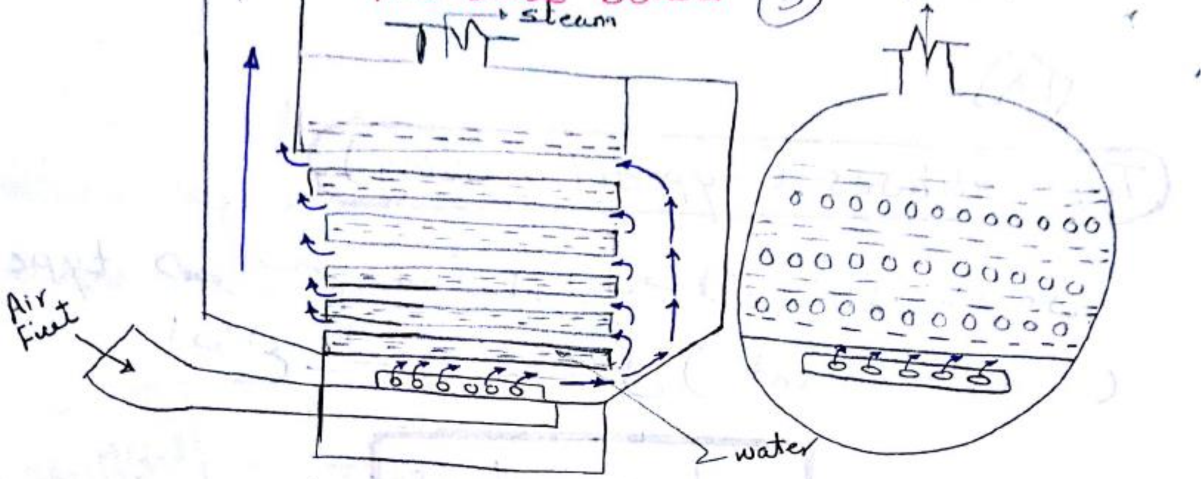
Classification of boilers :

1- **According to the relative position of water and hot gas**
   a) Water tube boiler
   b) Fire tube boiler
2- **According to method of furnace**
   a) External fired boiler
   b) Internal fired boiler
3- **According to method of water circulation**
   a) Natural water circulation
   b) Forced water circulation
4- **According to axis of shell**
   a) Horizontal boiler
   b) Vertical boiler
5- **According to use of boiler**
   a) Mobile boiler
   b) Stationary boiler





Fire tube boiler (5)



- Maximum operating pressure 24 bar
- Boiler Capacity 11 KW : 1100 KW

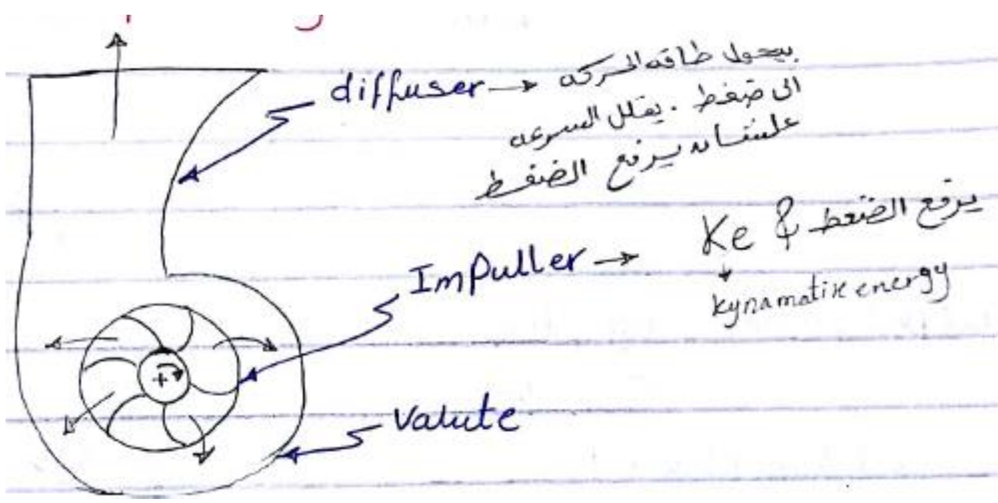
PUMPS

عبارة عن آلة لتحويل الطاقة الميكانيكية إلى طاقة هيدروليك

Classifications of Pumps

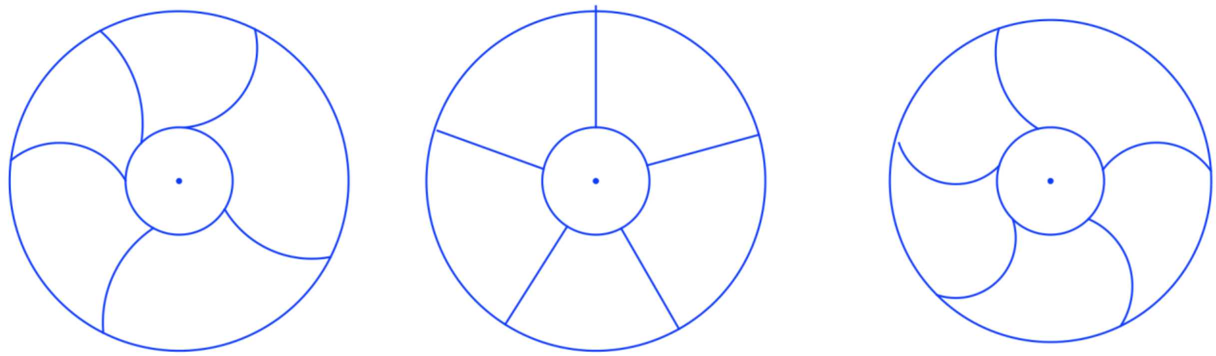
- Pumps
  - Non-Positive dosplacement pump
    - Centrifugal Pump
      - Radia Flow Pump
      - Axial Flow Pump
      - Mixed Flow Pumps
  - Positive displacement pump
    - Rotary
      e.g. Gear , Screw
    - Receprocating
      ترددية
      e.g. Piston pumps

Centrifugal Pump



Impuller	-يعمل على زياده السرعه بالتالي زياده ال K.E
Diffuser	يعمل على زياده الضغط بيحث زياده المساحه تقل السرعه فيزداد الضغط طبقا لمعادله برنولي (يحول طاقة الحركة إلى ضغط)

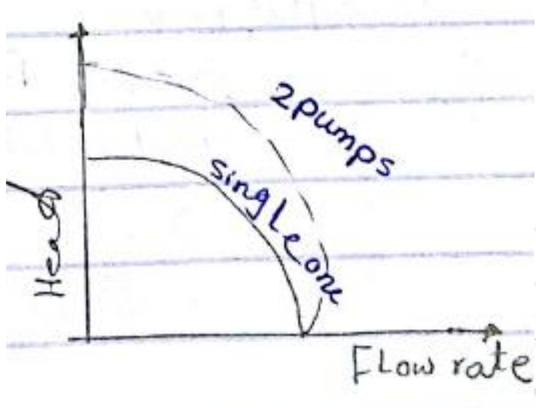
Classification of Pump Impeller

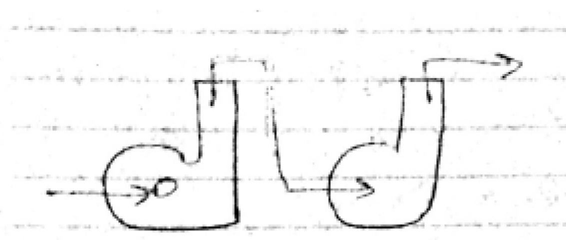


Backward Impeller Radian Impeller Forward Impeller

Pumps Connection

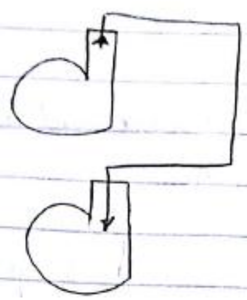
Pump In Series (A

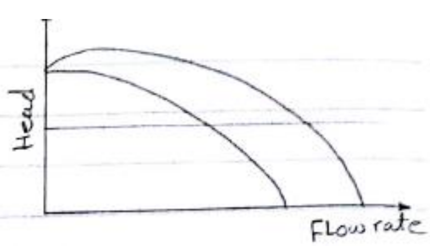




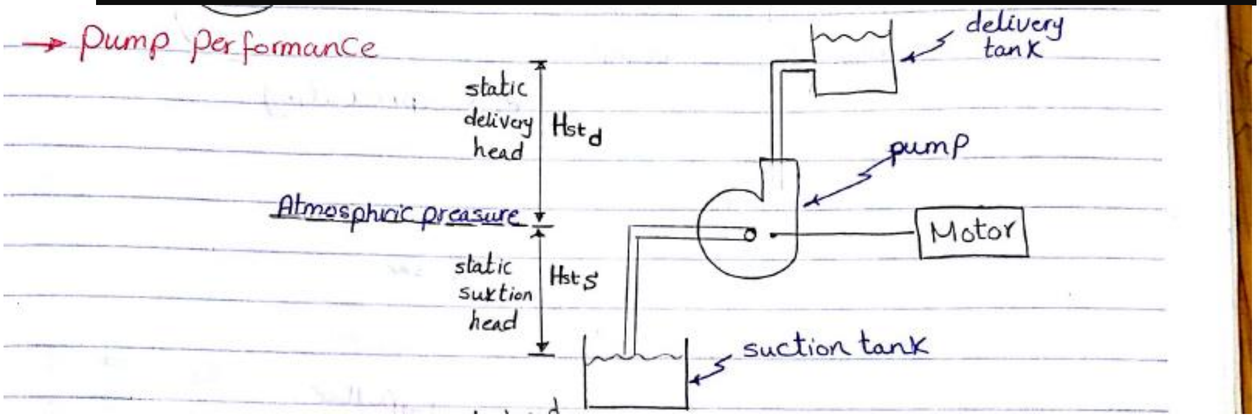
Pump in Parallel (B

to increas the flow rate for the sam head





Pump Performance



$$output\ Power = \rho g\ Q\ H_m = \gamma Q H_m$$

$$H_m = monometric\ head$$

$$Q = Volume\ flowrate = AV = \frac{\pi}{4} d_s^2 V_s = \frac{\pi}{4} d_d^2\ V_d$$

$$H_m = (\ H_{std} - H_{sts}\ ) + h_{fs} + h_{fd} + \frac{V_s^2}{2g}$$

$$h_{fs} = f_s \frac{L_s}{ds} \frac{V_s^2}{2g}\ ,\ \ h_{fd} = f_d \frac{L_d}{d_d} \frac{V_d^2}{2g}$$

Shaft Input Power

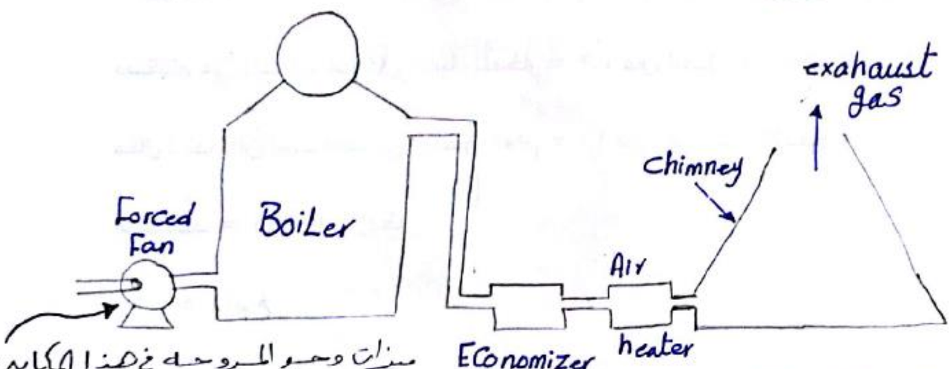
$$\eta\ = \frac{output\ Power}{shaft\ input\ Power} = \frac{\gamma Q H_m}{shaft\ input\ Power}$$

Draft System

Classification of Draft system

- Natural draft system لا نستخدمه لانه يحتاج ارتفاعات عاليه
- Mechanical Draft System
  - Forced Draft System
  - Induced Draft System
  - Balanced Draft System

Forced draft sys.



- عيوبها :
- المفاقيد الحراريه سوف تكون مرتفعه جداً لان الهواء في Boiler يكون تحت ضغط عالي عن الضغط الجوي

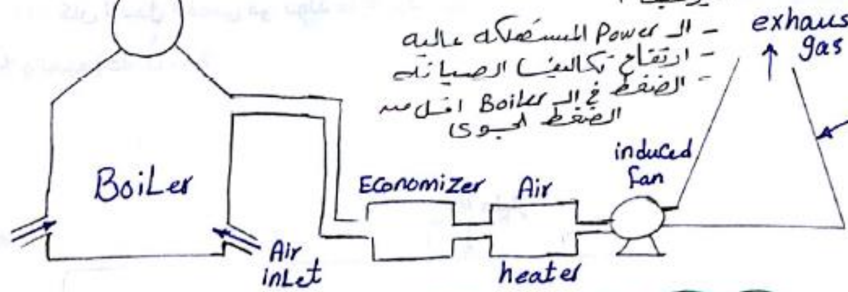
ميزات وجود المروحه في هذا المكان :
- الطاقه المستهلكه في المروحه منخفضه لان درجه حراره لسه مش عاليه
- تكلفه صيانه المروحه منخفضه لان الهواء نقي

- لانه درجة حرارة لسه مش عالية
- تكلفة صيانة المروحة منخفضة
لان الهواء نقى

Induced draft sys.

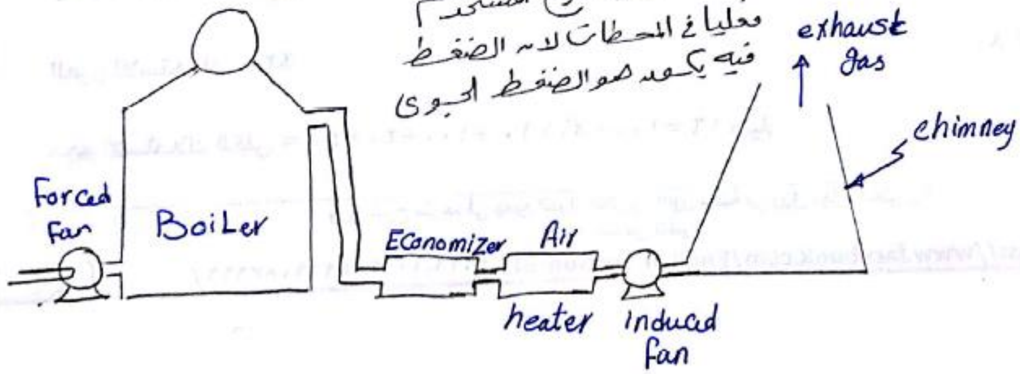
عيوبها :
- الـ Power المستهلكة عالية
- ارتفاع تكاليف الصيانة
- الضغط في الـ Boiler اقل من الضغط الجوى

* الضغط اقل من الضغط الجوى تقلل معامل انتقال الحرارة ∴ انتقال الحرارة من اللهب الى Boiler هيكون قليل



Balanced draft sys.

- هذا هو النوع المستخدم فعليا في المحطات لان الضغط فيه بكون هو الضغط الجوى



Heat Transfer :

Conduction :

$$Q = KA\frac{T_1 - T_2}{\delta} = \frac{T_1 - T_2}{\frac{\delta}{KA}} = \frac{T_1 - T_2}{R_{th}}$$

$$\boldsymbol{R_{th} = \frac{\delta}{KA}} \quad (\boldsymbol{cartezian}) \;;\quad \boldsymbol{R_{th} = \frac{\ln\left(\frac{r_2}{r_1}\right)}{2\pi KL}} \; (\boldsymbol{Cylindrical})$$

Convention :

1-Natural Convention 2- Forced Convention

$$Q = hA\,(T_s - T_\infty) = \frac{T_s - T_\infty}{\frac{1}{hA}} = \frac{T_s - T_\infty}{R_{th}}$$

$$\boldsymbol{R_{th} = \frac{1}{hA}} \; (\boldsymbol{cartezian}) \;;\; \boldsymbol{R_{th} = \frac{1}{2\pi r_0 Lh}} \; (\boldsymbol{cylindrical})$$

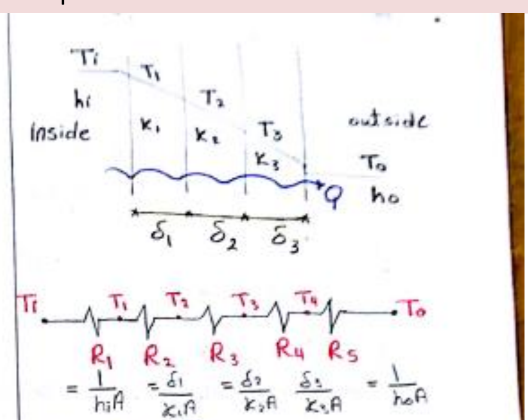
Radiation :

$$Q = \sigma\,\epsilon\,A\,(T_1^4 - T_2^4)$$

$$\sigma(stafen\ boltzman\ const) = 5.66 * 10^{-8}\ \frac{W}{m^2.k}\ ;"$$

$$\epsilon = emissivity = 0:1\ (black\ body)$$

Composite wall :

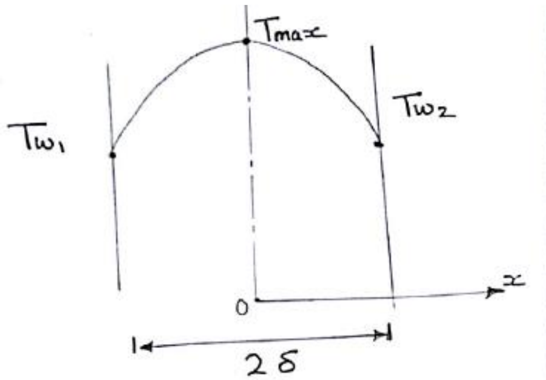


$$Q = \frac{T_i - T_o}{\sum R_{th}}$$

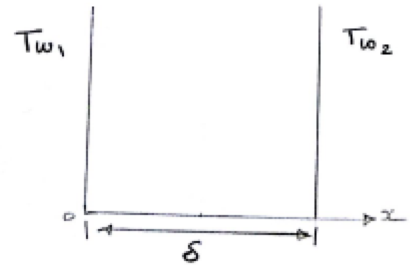
$$\sum R_{th} = R_1 + R_2 + R_3 + R_4 + R_5$$

$$Q = \frac{T_i - T_1}{R_1} = \frac{T_1 - T_2}{R} = \frac{T_2 - T_3}{R} \ldots$$

Steady State heat conduction with internal heat generation



For General Case



$$\frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2} + \frac{\partial^2 T}{\partial z^2} + \frac{q_v}{K} = 0$$

For one dimensional conduction

$$\frac{\partial^2 T}{\partial x^2} + \frac{q_v}{K} = 0 \;\Rightarrow\; \frac{d^2 T}{dx^2} = -\frac{q_v}{K}$$

Integrate

$$\frac{dT}{dx} = -\frac{q_v}{K}x + C_1$$

integerate

$$T = -\frac{q_v}{K}\frac{x^2}{2} + C_1\,x + C_2$$

$$B.C \;\; at\; x = 0 \rightarrow T = T_{w1} \;\; and \;\; x = \delta \rightarrow \;\; T = T_{w2}$$

$$T_{w1} = 0 + C_2 \qquad \therefore \;\; C_2 = T_{w1}$$

$$T_{w2} = -\frac{q_v}{K}\frac{\delta^2}{2} + \delta\;\; C_1 + T_{w1}$$

$$C_1 = \frac{T_{w2} - T_{w1}}{\delta} + \frac{q_v}{k}\frac{\delta}{2}$$

$$T = \frac{-q_v}{K}\frac{x^2}{2} + x\left(\frac{T_{w2} - Tw_1}{\delta} + \frac{q_v\delta}{2K}\right) + T_{w1}$$

$$\boldsymbol{T = T_{w1} + \frac{T_{w2} - T_{w1}}{\delta}\,x + \frac{q_v}{2K}\;(\delta\,x - x^2)}$$

Max Temp.

$$\frac{dT}{dx} = \frac{T_{w2} - T_{w1}}{\delta} + \delta * \frac{q_v}{2K} + 2x_0 * \frac{-q_v}{2K} = 0$$

$$x_0 = \frac{K}{q_v}\left(\frac{T_{w2} - T_{w1}}{\delta} + \delta * \frac{q_v}{2K}\right) = \frac{K}{q_v}\frac{T_{w2} - T_{w1}}{\delta} + \frac{\delta}{2}$$

In the equation (*) when $x = x_0$ ∴ we get T_{max}

يوجد نوعين من المسائل

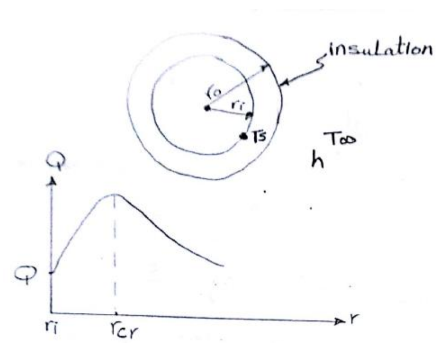
① يدينا $T_{w1} = T_{w2}$ ويدينا q_v مبدأ الاثبات من أوله

② يدينى $T_{w1} \neq T_{w2}$ هجيب x_0 وبالتعويض بالقيم اللى مديهالى وبعدين اروح اعوض في معادلة T_{max} واجيب قيمتها

1 $q_1 = \frac{KA}{\Delta x_1}\Delta T$

$q_2 = \frac{KA}{\Delta x_2}\Delta T$

Critical Thickness of insulation



$$Q = \frac{T_s - T_\infty}{\dfrac{\ln\left(\dfrac{r_0}{r_i}\right)}{2\pi K_{in} L} + \dfrac{1}{2\pi r_0 L h}}$$

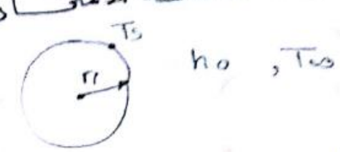
$$\frac{dQ}{dt} = 0 = \frac{0 - (T_s - T_\infty)\left(\dfrac{1}{2\pi K_{in} L r_0} - \dfrac{1}{2\pi r_0^2\, Lh}\right)}{\text{المقام}^2} = 0$$

$$\therefore\ \frac{1}{2\pi K_{in} L r_0} - \frac{1}{2\pi r_0^2\, Lh} = 0 \Rightarrow \frac{1}{2\pi K_{in} L r_0} = \frac{1}{2\pi r_0^2\, Lh} \quad \rightarrow \frac{1}{K_{in}} = \frac{1}{r_0 h}$$

$$\therefore\ r_0 = r_{cr} = \frac{K_{in}}{h}$$

$$critical\ thickness\ insulation\ = r_{cr} - r_i$$

امثلة لمسالة الامتحان



① Find the critical radious of insulation
② Find the rate of heat transfer
Per unite Length
→ with insulation
→ without insulation $r_o = r_{cr}$
→ with insulation $r_o = r_{cr} + 1.5$ Cm
→ with insulation $r_o = r_{cr} - 1.5$ Cm

مسائل هامة

A centrifugal pump deliver 0.2 m^3/s discharge of the water from suction reservoir in to delivery reservoir. The static suction head 5 m blow the atmospheric pressure and static delivery head 18 m above the atmospheric pressure. Diameter of suction and delivery pipe is 20 cm and length of suction pipe 5.5 m and length of delivery pipe is 20 m. the friction factor of pipe material 0.04 m. Determine the shaft power input to the pump. Given pump efficiency 0.86.

$$Q = 0.2\frac{m^3}{s} \;;\; H_{st_s} = -5 \;; H_{st_d} = 18 \;; d_s = d_d = 20 * 10^{-2}$$
$$L_s = 5.5\, m \;; L_d = 20\, m \;; f_s = f_d = 0.04\, m \;; \eta = 0.86$$

solution

$$Hydraulic\ Power = \gamma\, Q\, H_m$$

$$Q = 0.2 = AV = \frac{\pi}{4}\, d_s^2\, V_s = \frac{\pi}{4}\, d_d^2\, V_d = \frac{\pi}{4}\, (0.2)^2\, V$$
$$\therefore V = 6.366\frac{m}{s}$$

$$H_m = \left(H_{st_d} - H_{st_s} \right) + h_{fs} + h_{fd} + \frac{V_s^2}{2g}$$
$$h_{fs} = f_s\frac{L_s}{d_s}\frac{V_s^2}{2g} = \frac{(0.04)(5.5)}{0.2}\frac{(6.366)^2}{2 * 9.81} = 2.272$$

$$h_{fd} = \frac{(0.04)(20)}{0.2}\frac{(6.366)^2}{2 * 9.81} = 8.262$$

$$H_s = \left(18 - (-5) \right) + 2.272 + 8.262 + \frac{(6.366)^2}{2 * 9.81} = 35.6\, m$$

$$Hydraulic\ Power = 1000 * 9.81 * 0.2 * 35.6 = 69847.2\, watt$$

$$\eta = \frac{Hydraulic\ Power}{Shaft\ input}$$
$$\therefore shaft\ input = \frac{Hydraulic\ Power}{\eta} = \frac{69847.2}{0.86} = 81217.674\, watt = 81.218\, kW$$

Find the critical radius of insulation for the pipe with the outer diameter 7 cm surrounded by asbestos K = 0.181 W/m °C and exposed to air at a temperature of 10 °C with h = 3.5 W/m^2 °C. Also, find the heat losses from the pipe at 275 °C for the following cases:

- Pipe with the critical radius of insulation.
- Pipe without insulation.
- Pipe with the critical radius of insulation + 1.5 cm thick insulation.
- Pipe with the critical radius of insulation – 1.5 cm thick insulation.

$$r_i = 0.035\ m\ ; K = 0.181 \frac{W}{m^2 °C}\ ; T_\infty = 10°C\ ; h = 3.5\ ; T_s = 275°C$$

solution

$$r_{cr} = \frac{k}{h} = \frac{0.181}{3.5} = 0.052\ m$$

$$Q = \frac{T_s - T_\infty}{\left(\frac{\ln\left(\frac{r_o}{r_i}\right)}{2\pi KL} + \frac{1}{2\pi r_o L h}\right)}$$

$$\mathbf{1 -} \qquad \boldsymbol{r_0 = r_{cr}}$$

$$Q = \frac{275 - 10}{\frac{\ln\left(\frac{0.052}{0.035}\right)}{2\pi(0.181)1} + \frac{1}{2\pi * 0.052 * 1 * 3.5}} = 216.753\ watt$$

$$\mathbf{2 -} \qquad \boldsymbol{r_o = r_i}$$

$$Q = \frac{275 - 10}{\frac{1}{2\pi * 0.035 * 1 * 3.5}} = 203.968\ watt$$

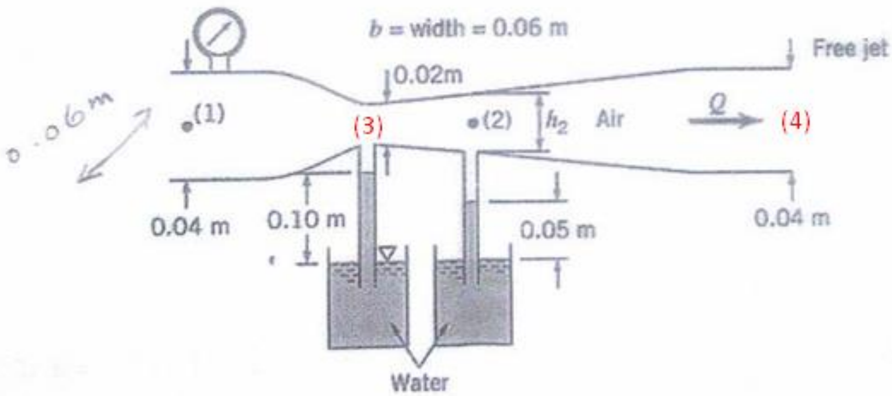
$$\mathbf{3-}\quad \boldsymbol{r_0 = r_{cr} + 1.5cm = 0.067\ m}$$

$$Q = \frac{275 - 10}{\frac{\ln\left(\frac{0.067}{0.035}\right)}{2\pi(0.181)1} + \frac{1}{2\pi * 0.067 * 1 * 3.5}} = 212.055\ watt$$

$$\mathbf{4-}\quad \boldsymbol{r_o = r_{cr} - 1.5cm = 0.037\ m}$$

$$Q = \frac{275 - 10}{\frac{\ln\left(\frac{0.037}{0.035}\right)}{2\pi(0.181)1} + \frac{1}{2\pi * 0.037 * 1 * 3.5}} = 207.378\ watt$$

(b) Air flows through a Venturi channel of rectangular cross section as shown in Fig. The constant width of the channel is 0.06 m and the height at the exit is 0.04 m. Compressibility and viscous effects are negligible. (a)Determine the flow rate when water is drawn up 0.10 m in a small tube attached to the static pressure tap at the throat where the channel height is 0.02 m. (b) Determine the channel height, at section (2) where, the water is drawn up 0.05 m. (c) Determine the pressure needed at section (1) to produce this flow.



نسمي نقطه ال throat بالنقطه (3)

ونقطه ال free jet بالنقطه (4)

$$two\ pre-informations:\ \ \rho_{air}=1.1\quad ;\quad P_{atm}=10^5 Pa=1\ bar$$

<u>أولا : إيجاد الضغط عند النقطتين 3 و 2 ،</u>

ارتفاع الماء يمثل الفرق بين الضغط عند النقط و الضغط الجوي وارتفاعه أي ان الضغط الجوي اكبر من الضغط عند النقط

$$P_3=P_{atm}-\rho gh=10^5-1000*9.8*0.1=\ 99020\ Pa$$
$$P_2=P_{atm}-\rho gh=10^5-1000*9.8*0.05=99510\ Pa$$

<u>ثانيا : تطبيق الاستمراريه وبرنوللي بين (3) و (4)</u>

$$\boldsymbol{\frac{P_3}{\rho g}+\frac{v_3^2}{2g}=\frac{P_4}{\rho g}+\frac{v_4^2}{2g}}$$
$$\rho_{air}=1.1\frac{kg}{m^3}$$
$$\frac{99020}{1.1*9.8}+\frac{1}{2*9.8}\ v_3^2=\frac{10^5}{1.1*9.8}+\frac{1}{2*9.8}\ v_4^2\rightarrow(1)$$
$$\boldsymbol{Q=A_3v_3=A_4v_4}$$
$$(0.02*0.06)v_3=(0.04*0.06)v_4\qquad\rightarrow\ (2)$$
$$solve\ eqns\ (1)\&(2)$$
$$v_3=48.7m/s\qquad,\qquad v_4=24.4\ m/s$$

$$Q=A_3v_3=A_4v_4=\boldsymbol{0.0584\ m^3/s}$$

ثالثا : نطبق برنوللي بين (2) و (4)

$$\frac{\boldsymbol{P_2}}{\boldsymbol{\rho g}}+\frac{\boldsymbol{v_2^2}}{\boldsymbol{2g}}=\frac{\boldsymbol{P_4}}{\boldsymbol{\rho g}}+\frac{\boldsymbol{v_4^2}}{\boldsymbol{2g}}$$

$$\frac{99510}{1.1*9.8}+\frac{1}{2*9.8}\quad v_2^2 = \frac{10^5}{1.1*9.8}+\frac{(24.4)^2}{2*9.8}$$

$$\therefore \quad v_2 = 38.55\, m/s$$

$$Q = A_2 v_2 = h_2 * 0.06 * 38.55 = 0.0584$$

$$\therefore \boldsymbol{h_2 = 0.052\ m}$$

المطلوب التاني : نطبق برنوللي واستمراريه بين 1 و 4

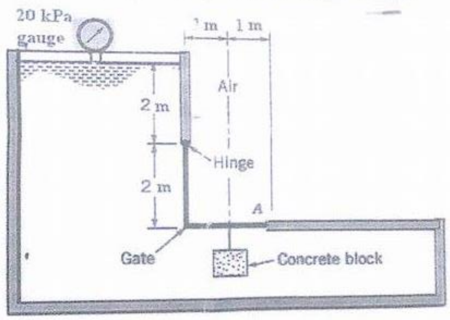
$$\because \quad Q = A_1 v_1 = A_4 v_4 \quad \therefore \quad v_1 = v_4 = 24.4$$

نطبق برنوللي

$$\frac{\boldsymbol{P_1}}{\boldsymbol{\rho g}}=\frac{\boldsymbol{P_4}}{\boldsymbol{\rho g}}$$

$$\therefore \quad \boldsymbol{P_1 = P_4 = 10^5\ Pa}$$

b- An L-shaped rigid gate is hinged at one end and is located between partitions in an open tank containing water as shown in Fig. A block of concrete is to be hung from the horizontal portion of the gate. (a) Determine the required volume of the block required to keep the gates closed as shown in Fig. (b) Required the optimal position of the black to keep the gated closed as shown in Fig. if the volume of black is 12 m^3. Take the specific gravity of concrete 2.4.



نفرض عرض البوابه دي 1 متر

القوة هتاثر على البوابه هتتقسم 2
قوة افقية و رأسيه
(هنفرض ان g=10)

1- القوة الأفقية (العادية اللي احنا نعرفها)
القوة الافقية بتاثر على الجزء الرأسي من البوابه

$$F_R = \rho g\, h_c\, A = 1000 * 10 * 3 * (2 * 1) = 60000\, N$$

$$h_R = h_c + \frac{Ixy}{h_c A} = 3 + \frac{1\,\frac{(2)^3}{12}}{3 * (2 * 1)} = 3.1\, m$$

2- القوة الرأسيه
قوة تؤثر على الجزء الافقي من البوابه
قوة ناتجه من وزن الماء (بتتحسب زي فوق بس الارتفاع hc بيكون كامل)

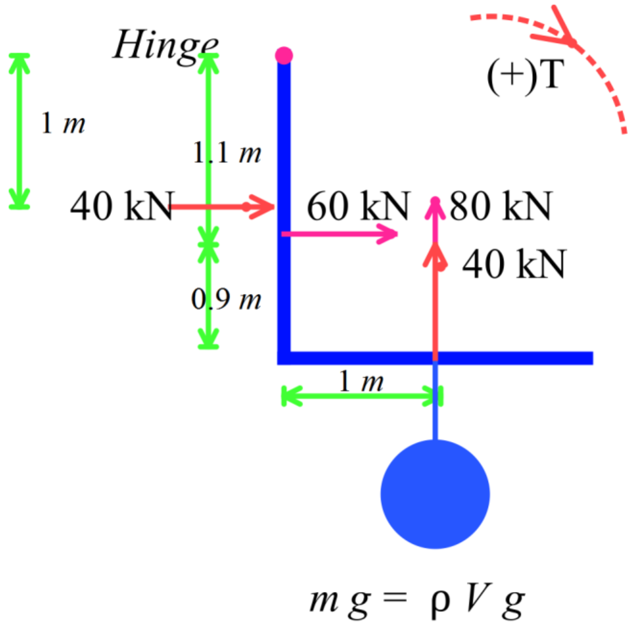
$$FR_2 = \rho g\, h_{c2}\, A = 1000 * 10 * 4 * (2 * 1) = 80000\, N$$

3- تؤثر في منتصف البوابه (قوة ناتجه من الضغط اللي هو 20kPa)

$$P = \frac{F}{A} \Rightarrow F = PA = 20000 * (2 * 1) = 40000\, N$$

تؤثر في منتصف البوابه من الجانبين الافقي و الراسي بنفس المقدار

وتكون محصله القوة والعزوم كالآتي



$$\sum T = 0$$

$$mg * 1 = \rho g V * 1 = 2400 * 10 * V * 1 = 60000 * 1.1 + 40000 * 1 + 80000 * 1 + 40000 * 1$$

$$\therefore \quad V = 9.4\, m^3$$

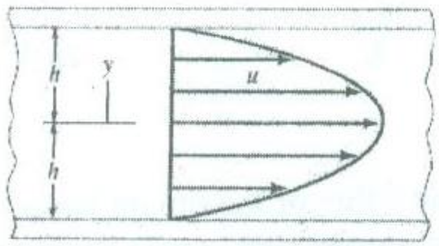
المطلوب التاني

$$2400 * 10 * 12 * x = 60000 * 1.1 + 40000 * 1 + 80000 * 1 + 40000 * 1$$

$$\boldsymbol{x = 0.784 \;\; m}$$

The velocity distribution for the flow of a Newtonian fluid between two wide, parallel plates is given by the equation

$$u = \frac{3V}{2}\left[1 - \left(\frac{y}{h}\right)^2\right]$$



Where V is the mean velocity. The fluid has a viscosity of 0.04 pa. s. When V= 2 m/s and h = 0.1 m determine: (a) the shearing stress acting on the bottom wall, and (b) the shearing stress acting on a plane parallel to the walls and passing through the centerline (midplane).

$$\mu = 0.04\ Pa.s \quad ; \quad V = 2\frac{m}{s}\ ; h = 0.1$$

$$\tau = -\mu\ \frac{du}{dy} = -\mu\ \frac{d}{dy}\left[3 - 3 * \frac{y^2}{0.01}\right] = -\mu\left(-\frac{6}{0.01}\ y\right) = 24\ y$$

$a)\ at\ \ y = h$

$\tau = 24\ (0.1) = 2.4\ N/m^2$

$b)\ at\ \ y = 0$

$\tau = 0$

Four-stroke engine operating at 800 rpm, rate of fuel consumption 113 gm per 4 min, torque 80 N.m the engine with 6 cylinder each have a diameter 125 mm and stroke 175 mm, the calorific value of fuel 42000 kJ/kg.

Calculate:

- Brake power.
- Brakes mean effective pressure.
- Brake specific fuel consumption.
- Brake thermal efficiency.

$$z = 2\,;N = 800\,rpm\ \ ;\dot{m}_f = \frac{113gm}{4Min} = \frac{113 * 10^{-3}}{4 * \left(\frac{1}{60}\right)} = 1.695\ kg/h$$

$$T = 80\ N.m\,;\ \ n = 6\,;d = 125 * 10^{-3}\ \ m\ ;S = 175 * 10^{-3}m$$

$$C.V = 42000\frac{kJ}{Kg}$$

Solution

$$P_b = T * \omega = \ T * \left(\frac{2\pi N}{60}\right) = 80 * \left(\frac{2 * \pi * 800}{60}\right) = \ \ 6702.06\ \ watt$$

$$C = \frac{A * s * n * N}{60 * z} = \frac{\frac{\pi}{4}(125 * 10^{-3})^2 * 175 * 10^{-3} * 6 * 800}{60 * 2} = \ 0.086\ \ m^3/s$$

$$b.m.e.p = \frac{P_b}{C} = \frac{6702.06}{0.086} = \ 77930.93\,watt$$

$$SFC_b = \frac{\dot{m}_f}{P_b} = \frac{1.695}{77.93} = 0.0218\frac{Kg}{kW.h}$$

$$Q = \ \dot{m}_f * C.V \ = \frac{1.695}{60 * 60} * 42000 \ = 19.775\ kJ/s$$

$$\eta_{th_b} = \frac{P_b}{Q} = \frac{6.7}{19.775} * 100 = 33.88\%$$

Determine the value of maximum temperature and its position in the plate with the uniform distributed heat source having a volumetric rate $\dot{q}_v = 8 * 10^6$ W/m³, the plate thickness 20 mm, the thermal conductivity of the plate material K = 20 W/m°C, the inside surface of the wall is exposed to the fluid with convective heat transfer coefficient of 400 W/m² °C and 25 °C, and the other surface is exposed to the fluid with convective heat transfer coefficient of 300 W/m² °C and 20 °C.

$$plate: \; q_v = 8 * 10^6 \frac{W}{m^3} \;\; ; \delta = 20 * 10^{-3} \, ; K = 20 \frac{W}{m°C}$$

$$fluid\ 1: h = 400 \frac{W}{m^2} \quad T_{\infty 1} = 25\ °C$$

$$fluid\ 2: h = 300 \frac{W}{m^2} \quad T_{\infty 2} = 20\ °C$$

الأول هترمي الاثبات لحد ما توصل للمعادله :

$$x_0 = \frac{K}{q_v}\left(\frac{T_{w2} - T_{w1}}{\delta} + \delta * \frac{q_v}{2K}\right) = \frac{K}{q_v}\frac{T_{w2} - T_{w1}}{\delta} + \frac{\delta}{2}$$

ثم

$$Q = const$$

$$\frac{T_{w1} - T_{\infty 1}}{\frac{1}{h_1 A}} = \frac{T_{w1} - T_{w2}}{\frac{\delta}{KA}} = \frac{T_{w2} - T_{\infty 2}}{\frac{1}{h_2 A}}$$

$$\frac{25 - T_{w1}}{\frac{1}{400}} = \frac{T_{w1} - T_{w2}}{\frac{20 * 10^{-3}}{20}} = \frac{T_{w2} - 20}{\frac{1}{300}}$$

$$T_{w1} = 23.17\ °C \; ; \; T_{w2} = 22.43\ °C$$

$$x_0 = \frac{K}{q_v}\frac{T_{w2} - T_{w1}}{\delta} + \frac{\delta}{2} = 0.0099075\ m$$

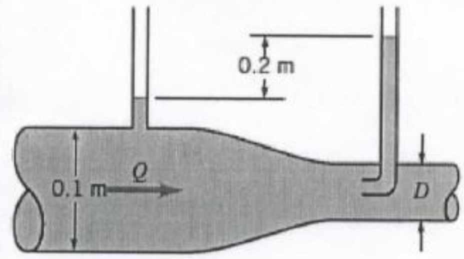
$$\boldsymbol{T = T_{w1} + \frac{T_{w2} - T_{w1}}{\delta} x + \frac{q_v}{2K} \left(\delta x - x^2\right) = 46.204}\ °C$$

Question No. 6

Determine the value of t_o and coordinate x_o of the maximum temperature in the plate with the uniform distributed heat source having a volumetric rate $q_v = 8*10^6$ W/m^3, the plate thickness 10 mm, the thermal conductivity of the plate material K = 20 W/m°C, the surface temperature of the plate are t_{w1} = 80 °C and t_{w2} = 80 °C, respectively.

دي زي اللي فوق بس اسهل كتير مديني درجه الحرارة جاهزة

b) Water flows through the pipe contraction shown in Fig. For the given 0.2-m difference in the manometer level, determine the flow rate as a function of the diameter of the small pipe, D.



$$\frac{\pi}{4}(0.1)^2 v_1 = \frac{\pi}{4} D^2 v_2$$

$$(0.1)^2 v_1 = D^2 v_2$$

$$\frac{P_1}{\rho g} + \frac{v_1^2}{2g} = \frac{P_2}{\rho g} + \frac{v_2^2}{2g}$$

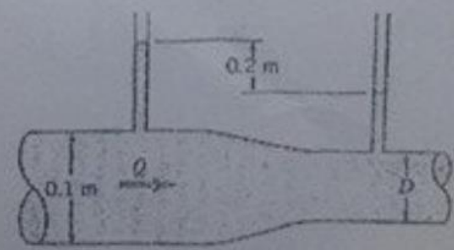
$$total\ head\ (2) - static\ head\ (1) = 0.2$$

$$\frac{v_1^2}{2g} = \frac{P_2}{\rho g} + \frac{v_2^2}{2g} - \frac{P_1}{\rho g} = 0.2$$

$$v_1 = \sqrt{0.2 * 2 * 9.8} = 1.98\, m/s$$

$$Q = \frac{\pi}{4}(0.1)^2\,(1.98\,) = \frac{\frac{\pi}{4}D^2(0.0198)}{D^2} = 0.01555\ m^3/s$$

b) Water flows through the pipe contraction shown in Fig. For the given 0.2-m difference in the manometer level, determine the flow rate as a function of the diameter of the small pipe, D.



$$\frac{P_1}{\rho g}+\frac{v_1^2}{2g} = \frac{P_2}{\rho g}+\frac{v_2^2}{2g}$$

$$static\ (1) - static\ (2) = 0.2$$

$$\frac{P_1}{\rho g}-\frac{P_2}{\rho g} = \frac{v_2^2}{2g}-\frac{v_1^2}{2g} = 0.2$$

$$v_2^2 - v_1^2 = 2 * 9.8 * 0.2 = 3.92$$

$$v_1 = \sqrt{v_2^2 - 3.92}$$

$$A_1 v_1 = A v_2$$

$$v_1 = \frac{A_2 v_2}{A_1}$$

$$\frac{D_2^2 v_2}{(0.1)^2} = \sqrt{v_2^2 - 3.92}$$

$$\frac{D_2^4 v_2^2}{(0.1)^4} = (v_2^2 - 3.92)$$

$$v_2^2\left(\frac{D_2^4}{(0.1)^4} - 1\right) = -3.92$$

$$v_2 = \sqrt{\frac{-3.92}{\left(\frac{D_2^4}{(0.1)^4} - 1\right)}}$$

$$Q = \frac{\pi}{4} D^2 \sqrt{\frac{-3.92}{\left(\frac{D_2^4}{(0.1)^4} - 1\right)}}$$

فانكشن في D ولا مش فانكشن في الD يا متعلمين يابتوع الميكانيكا XD

9- Determine the flow rate through the pipe in Fig. 7.

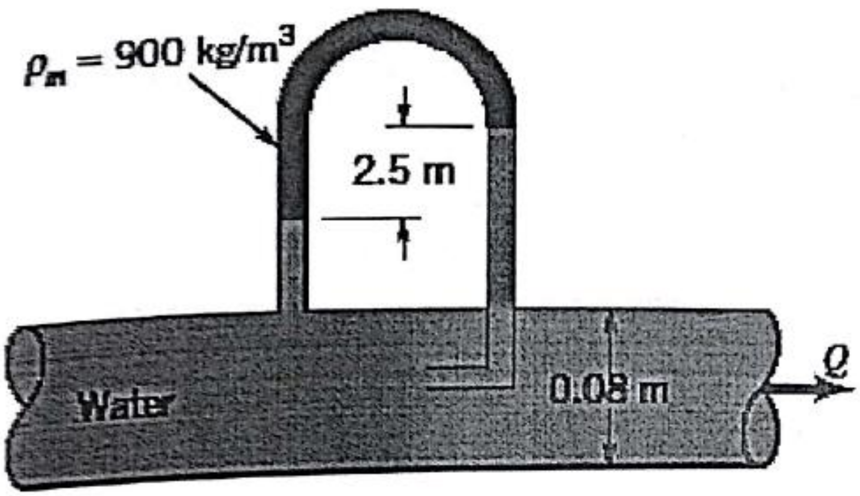


Fig. 7

$$\frac{v^2}{2g} = 2.5$$

$$v = \sqrt{2 * g * 2.5} = 7\frac{m}{s}$$

$$Q = \frac{\pi}{4}(0.08)^2 * 7 = 0.035\ m^3/s$$

4. In the case shown in Fig. 2, water at a flow rate of Q = $0.2 m^3/s$ is supplied to the cylindrical water tank of diameter 1 m discharging through a round pipe of length 4 m and diameter 15 cm. How deep will the water in the tank be?

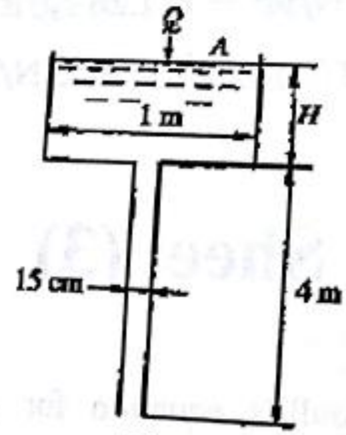
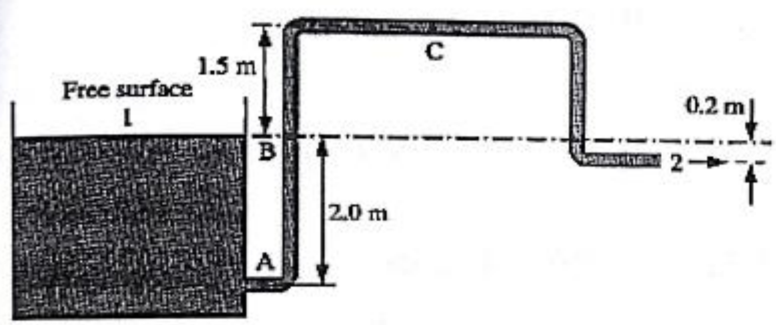


Fig. 2

An open tank of water has a pipeline of uniform diameter leading from it as shown below. Neglecting all frictional effects, determine the velocity of water in the pipe and the pressure at points A, Band C.



Solution

The Bernoulli equation (named after Daniel Bernoulli) is

$$\frac{p_1}{\rho g}+\frac{v_1^2}{2g}+z_1=\frac{p_2}{\rho g}+\frac{v_2^2}{2g}+z_2$$

To determine the velocity in the pipe, the Bernoulli equation is applied between the free surface (point 1) and the end of the pipe (point 2) which are both exposed to atmospheric pressure. That is

$$p_1=p_2=p_{atm}$$

The tank is presumed to be of sufficient capacity that the velocity of the water at the free surface is negligible. That is

$$v_1\approx 0$$

$$\begin{aligned} v_2 &= \sqrt{2g(z_1-z_2)} \\ &= \sqrt{2g\times 02} \\ &= 1.98\ \mathrm{ms}^{-1} \end{aligned}$$

The average velocity is the same at all points along the pipeline. That is

$$v_2=v_A=v_B=v_C$$

The pressure at A is therefore

$$\begin{aligned} p_A &= \rho g\left(z_1-z_A-\frac{v_A^2}{2g}\right) \\ &= 1000g\times\left(2-\frac{1.98^2}{2g}\right) \\ &= 17{,}658\ \mathrm{Nm}^{-2} \end{aligned}$$

The pressure at B is

$$p_B = \rho g \left(z_1 - z_B - \frac{v_B^2}{2g} \right)$$

$$= 1000g \times \left(0 - \frac{1.98^2}{2g} \right)$$

$$= -1962 \text{ Nm}^{-2}$$

Finally, the pressure at C is

$$p_C = \rho g \left(z_1 - z_C - \frac{v_C^2}{2g} \right)$$

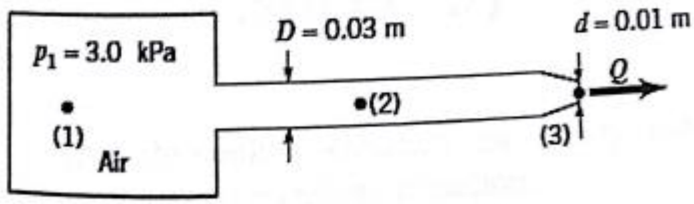
$$= 1000g \times \left(-1.5 - \frac{1.98^2}{2g} \right)$$

$$= -16{,}677 \text{ Nm}^{-2}$$

The average velocity in the pipeline is 1.98 ms^{-1} and the pressures at points A, B and C are 17.658 kNm^{-2}, -1.962 kNm^{-2} and -16.677 kNm^{-2}, respectively.

Example:

Air flows steadily from a tank, through a hose of diameter $D = 0.03$ m and exits to the atmosphere from a nozzle of diameter $d = 0.01$ mas shown in Fig. The pressure in the tank remains constant at 3.0 kPa (gage) and the atmospheric conditions are standard temperature and pressure. Determine the flowrate and the pressure in the hose.



SOLUTION

If the flow is assumed steady, inviscid, and incompressible, we can apply the Bernoulli equation along the streamline shown as

$$p_1 + \tfrac{1}{2}\rho V_1^2 + \gamma z_1 = p_2 + \tfrac{1}{2}\rho V_2^2 + \gamma z_2$$
$$= p_3 + \tfrac{1}{2}\rho V_3^2 + \gamma z_3$$

With the assumption that $z_1 = z_2 = z_3$ (horizontal hose), (large tank), and (free Jet), this becomes

$$V_3 = \sqrt{\frac{2p_1}{\rho}}$$

and

$$p_2 = p_1 - \tfrac{1}{2}\rho V_2^2$$

The density of the air in the tank is obtained from the perfect gas law, using standard absolute pressure and temperature, as

$$\rho = \frac{p_1}{RT_1}$$

$$= [(3.0 + 101)\ \text{kN/m}^2] \times \frac{10^3\ \text{N/kN}}{(286.9\ \text{N·m/kg·K})(15 + 273)\text{K}}$$

$$= 1.26\ \text{kg/m}^3$$

Thus, we find that

$$V_3 = \sqrt{\frac{2(3.0 \times 10^3\ \text{N/m}^2)}{1.26\ \text{kg/m}^3}} = 69.0\ \text{m/s}$$

or

$$Q = A_3V_3 = \frac{\pi}{4}d^2V_3 = \frac{\pi}{4}(0.01\ \text{m})^2(69.0\ \text{m/s})$$

$$= 0.00542\ \text{m}^3/\text{s}$$

$$A_2V_2 = A_3V_3$$

$$V_2 = A_3V_3/A_2 = \left(\frac{d}{D}\right)^2 V_3 = \left(\frac{0.01\ \text{m}}{0.03\ \text{m}}\right)^2(69.0\ \text{m/s}) = 7.67\ \text{m/s}$$

$$p_2 = 3.0 \times 10^3\ \text{N/m}^2 - \tfrac{1}{2}(1.26\ \text{kg/m}^3)(7.67\ \text{m/s})^2$$

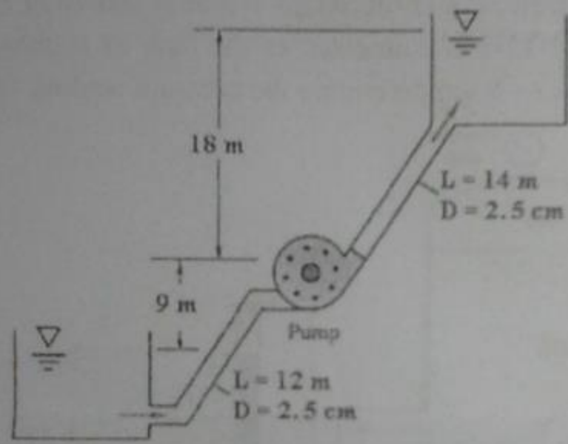
$$= (3000 - 37.1)\text{N/m}^2 = 2963\ \text{N/m}^2$$

Question No. 6

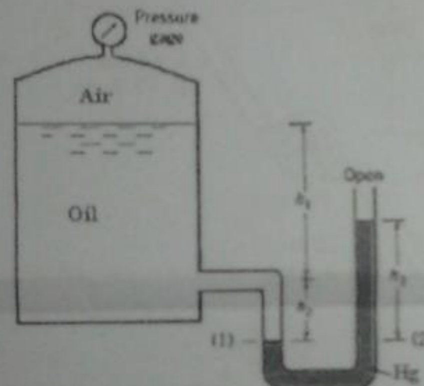
An exterior wall of a house consists of 10.2 cm brick (k=0.7 w/m. k) and 3.8 cm gypsum plaster (k=0.48 w/m. k). What thickness of loosely packed rock wool insulation (k=0.065 w/m. k) should be added to reduce the heat transfer through the wall by 75%.

Question No. 4

A centrifugal pump delivers 200 lit/min discharge of the water from suction reservoir in to delivery reservoir as shown in Fig. If the friction factor of pipe material 0.04. Determine the shaft power input to the pump. Given pump efficiency 92%.



b) A closed tank contains compressed air and oil $SG_{oil} = 0.9$ as is shown in Fig. A U-tube manometer using mercury $SG_{Hg} = 13.6$ is connected to the tank as shown. For column heights $h_1 = 36$ cm, $h_2 = 6$ cm and $h_3 = 9$ cm determine the pressure reading of the gage.



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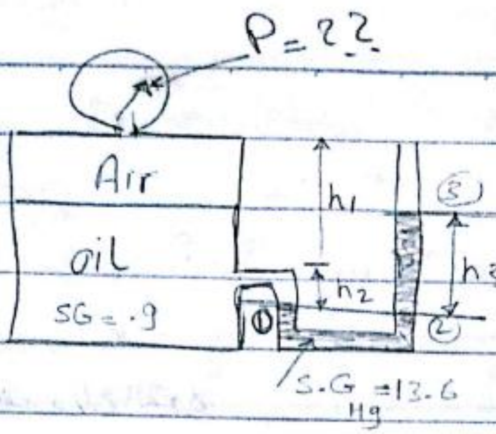

مسألة مبتكرة :

Given/

$h_1 = 36$ cm

$h_2 = 6$ cm

$h_3 = 9$ cm

$$P_1 = P_2$$

$$P_{air} + \rho_{oil} g h_1 + \rho_{oil} g h_2 = \rho_{Hg} h_3 g$$

$$P_{air} = \rho_{Hg} h_3 g - \rho_{oil} g (h_1 + h_3)$$